HIDDEN

HAM ANTENNAS

by

FRANK P. HUGHES

VE3DQB

TIARE PUBLICATIONS

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INTRODUCTION

Happy is the ham or SWL who can blithely set up a beam on a tower or a long, longwire, or ring his lot with a loop antenna, or build a rhombic or put up an antenna farm without anyone complaining. You need to live deep in the country if you want to do that! In towns and cities the ham encounters covenants, ordinances, zoning and by-laws; ill-designed, ill-maintained TVs and audio equipment, and irrational neighbors. Each of these factors needs consideration if you intend to buy a house. Trying to get around such obstacles after you've made the purchase is time consuming and requires deep pockets, especially if a lawyer becomes involved. A renter, besides all of this, has a landlord to placate if he wants to put up a beam.

If irrational neighbors are the only problem, that can be evaded. A knowledge of psychology (or perhaps psychiatry!) is essential in all dealings with neighbors.

Here's a way to make the neighbors think twice before complaining. Put up a beam and rotator, carry the lead-in to the shack and connect it to a *receiver.* Do not even have a transmitter in the house! Leave the transmitter with a friend or relative for a while. Use the receiver every evening, turning the antenna in all directions to find the best signal. Wait for the complaints: "You are interfering with my television!" Deny the accusation and suggest the neighbor complain to the FCC. When the inspector calls, show him your shack and let him do the explaining to the neighbors. Then, a week or ten days later you can install the transmitter, but don't use high power, at least not for the first month or so.

To use your ham antenna under conditions which amount to a prohibition of antennas, remember that those who write such laws and regulations rarely have the vaguest idea of what they are forbidding. Most of them just want a "nice" neighborhood. The fact that there are fellow human beings in the neighborhood who don't want to spend all their spare time watching TV, playing cards or golfing is quite beyond their understanding. This means that so long as what you put up does not look like a ham antenna it's not likely to be questioned.

This book provides some suggestions on antennas that will not attract attention. I am sure that with these antenna ideas, coupled with your own ingenuity, you will be able to set up an unnoticeable antenna and use it to work the world.

Besides these disguised antennas there are also designs for indoor antennas. Although these will not be as good as well-designed outdoor antennas, they will get you on the air and net you excellent QSOs when conditions are right.

One other thing: if you are in these difficult situations, use low power. Let's face it - ordinary home entertainment electronics can scarcely be expected to operate correctly if placed right beside a powerful transmitter. Indoors, too, high power can put high voltage in wires not directly connected to anything. Set 100 watts as the maximum power you'll use. Believe me, I have worked the world with much less than that. There are other worthwhile challenges. The amateur radio magazines feature a good deal about QRP operating, milliwatting and miles-per-watt. Low power has real challenges for us all! (See Tiare Publications' *Low Power Communications, Vol. 1 - Basic QRP* and *Vol. 2 - Advanced QRP Operating.*)

Antennas respond and radiate power according to their length in wavelengths, so I use that term in this book rather than frequency. The radiation pattern of an antenna a half-wavelength long is the same, regardless of whether it is one meter long (for two meter use) or 40 meters long (for the 80 meter band).

Normally I never write about antennas I have not tried personally but in this book I do cover some antenna ideas based on the recommendation of others. For example, I have never hidden an antenna in a flagpole. I'm sure, though, that you will be able to satisfactorily use any of the designs set out here, even though it won't be as effective as a well-made beam, half a wavelength or more above the ground.

ONE

1

HIGH FREQUENCY OUTDOOR ANTENNAS

Antennas work best out-of-doors and positioned as high as can be managed. An outdoor antenna can be either hidden or disguised. The parts of the antenna are the radiating element(s), the download and the matching device. (See Figure 1)

The best length, and the easiest to load, is a half wavelength at the chosen frequency. The wire is center-fed, cut in the middle to form the feedpoint. This half-wave dipole has a center impedance at its resonant frequency near 70 ohms, so it can be connected to a low power transmitter by a length of 50 or 75 ohm coaxial cable, then it will serve the amateur band for which it is cut.

Put the center of the antenna at the house. This enables you to hid the download. The two elements are spread out to anchor points using invisible wire. "Invisible" wire is thin, enamelled wire, supported at each end by lengths of nylon kite string. A 35 gauge wire cannot be seen at a distance of 15 feet, a 28 gauge at 30 feet. If you can find it, "four thousand" stainless steel recorder wire will last a very long time, and once it is dirty, will be invisible. Pass it through a smoky flame to dull it before you put it up.

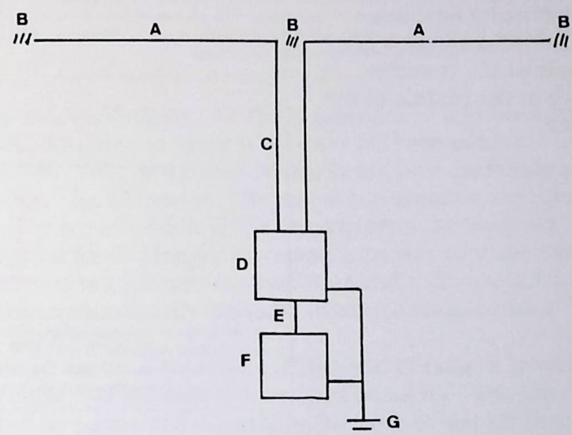

Fig. 1 - *The parts of an antenna. (A) and (A) are the radiating elements. These used to be called the "aerial." The elements are insulated from each other and from the ground by insulators (B). (C) is the downlead. If (AA) is a half wavelength overall then (C) can be coaxial line and no antenna tuner is needed. If the downlead is of twinlead then the antenna can be used on several bands, but an antenna tuner is essential. (D) is the antenna tuner, (E) the 50 ohm coax between the tuner and the transceiver (F). (G) is the ground lead. Notice that the tuner is connected directly to ground.*

The elements need not spread on opposite sides in a straight line or horizontally. They can go out at an angle to each other, in any direction, so long as they do not run too close together. If the elements slope downwards the antenna is called a *sloper*.

If you have a short front lawn and a long backyard, a good way of feeding a half-wave antenna is by connecting a length of TV twinlead to one end of it. This is called a *zepp* antenna. It was invented a long time ago to keep high voltages away from "gasbags" or "zepplins," which were filled with explosive hydrogen. The zepp has an advantage for hidden outdoor antennas in that the downlead comes close to the house where it is less conspicuous. It is difficult to disguise a coax downlead if it is somewhere in the middle of the garden.

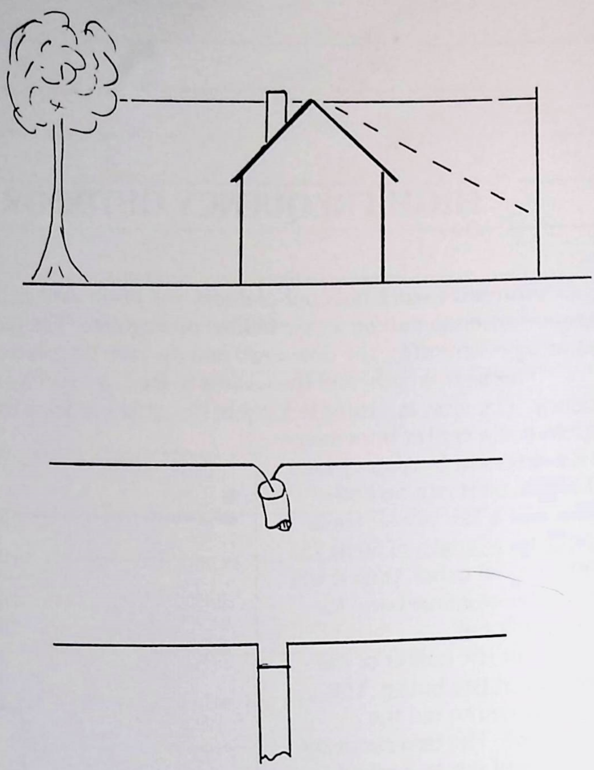

Figure 2 - *A center-fed dipole is ideally strung in a straight line. If it is more convenient it can be set up with the middle where the feedline is and higher or lower than either or both of the elements. There will be a slight loss of efficiency so long as the elements are not too close together. The dashed line in Figure 2A shows a possible sloper position. Figures 2B and 2C are connections for coax and twinlead, respectively.*

The zepp needs an antenna tuner. This is the "gearshift" that makes the antenna look like 50 ohms to the transmitter (see Chapter 6). It is needed because the impedance of the twinlead (300 ohms) does not match the 50 ohms of the transceiver. Strictly speaking, a 600 ohm downlead should be used, but for low power the twinlead will work well. I don't advise a balun because, for the kinds of antennas we are discussing, many things may affect the tuning. Low antennas or those close to metallic objects may have impedances quite different from what the textbooks say they should be, and baluns are set at an unchangeable transformation ratio. A four-to-one balun will match a 300 ohm impedance to 50 ohms, but the impedance of a hidden antenna cannot usually be guaranteed. An antenna tuner takes care of these effects.

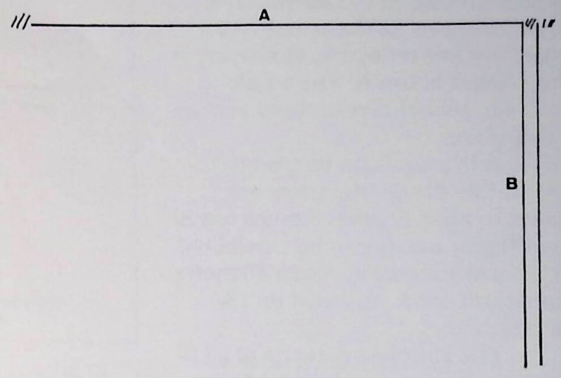

Figure 3 - *The zepp antenna is a single half-wave long element, fed at one end (B) with (ideally) a 600 ohm line. Practically, 300 ohm TV twinlead will do for low power use. Use an antenna tuner anyway. Notice that one of the twinlead conductors is connected to the antenna, the other to nothing, but is supported between the two insulators.*

The dipole can also be "trapped," that is, a tuned circuit is put into each side of the antenna, at the length needed for, say, 10 meters. The rest of the antenna completes the length for 15, 18 or 20 meters. The tuned circuit is designed to stop the antenna current at 10 meters while passing that for the longer wavelength. In this way the same antenna "looks like" a 10 meter antenna to a 10 meter transmitter and a 20 meter antenna to a 20 meter rig. More traps can be used to match the same dipole to three or four bands. However, it is difficult to hide the traps.

There is another way of using a center-fed antenna. If, instead of coax, a length of TV twinlead is connected to the center, the antenna can be used on all the high frequency bands. This antenna cannot be connected directly to the coax outlet on the transceiver. Instead, the shack-end of the twinlead goes to an antenna tuner, which matches the antenna and twinlead to the transmitter. TV twinlead is satisfactory for low power use. Open-wire line must be used for high powers, but then the antenna becomes hard to hide.

An antenna a quarter-wavelength long, set vertically above a good conductive ground, is called a *Marconi*. It can be fed with 50 ohm coax, center conductor to the antenna, shield braid to ground. While it looks delightfully simple and easy to disguise (see below) it has the drawback that a good conductive ground is hard to find, other than on a boat. Commercial medium wave AM transmitters use Marconis and a fortune must be spent burying a hundred or so heavy copper radial conductors under the mast-antenna to provide a ground.

To see how it works, put a mirror flat on a table and balance a pencil upright on the mirror. The "quarter-wave" of the pencil has a quarter-wave reflection appearing in the ground below it. The whole antenna, real plus reflection, acts as a half-wave.

A Marconi can be trapped, too. In this design the traps are easier to hide. Several dipoles tuned to different bands can be connected to the same feedline. And a 40 meter dipole will work very well on 15 meters, too.

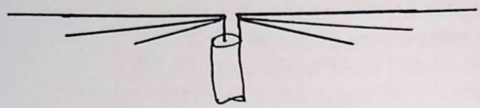

Figure 4 - *Connecting two or three dipoles together at the feedpoint makes a multiband antenna.*

The simplest antenna of all is a length of wire. Any length of wire can be loaded at any frequency and will radiate efficiently. Any wire, or any well-bonded conductor can make a worthwhile antenna. There is no downlead and the conductor must be tuned to the operating frequency by an antenna tuner. Such an antenna can be used for every frequency from six meters up to 160 meters. It could be used on shorter wavelengths too, but two meters and down are more suited to smaller antennas.

A common solution to the hidden antenna problem is a fixed longwire outdoor antenna. The house end can be fixed by a small screw eye and the far end to a tree or pole - anything over six feet high. Keep in mind that the tree itself will sway in the wind. Depending on the strength of the invisible wire used, the tree end should have either a length of bungee cord (a stretchable rubber rope) or a pulley and weight arrangement. Never tie the end to a thin branch since it is most susceptible to wind.

If there is no useable tree, set up a decorative arbor in the middle of the back fence, complete with rustic seat. At the top of this tie a foot or so of thin nylon cord to provide insulation. Tie invisible wire (its gage proportional to the distance from your neighbors) to the cord and carry it to the house. Fit a tiny screw eye to the side of the shack window and fasten the wire to this with another foot of nylon cord. Bring the wire indoors to the antenna tuner. Keep an eye on the insulation as it passes under the sash.

This "invisible wire" antenna will not last as long as one made from the usually recommended but more visible materials, such as phosphor bronze or hard-drawn copper. With ordinary luck it will last a few years, unless an unfortunate bird collides with it. The material is cheap, so when you have to re-do it your loss is mostly in the form of time.

This antenna can be modified for single band operation. Del, G3DLN, set up an effective 20 meter invisible antenna between the tree and the chimney using 115 feet of wire. The wire was tied to the tree with nylon as usual. Then, at 35 feet from the knot, it was tied to one end of a three foot length of nylon. (Don't try to shorten this three foot length or the loop below it will tangle.) The next 35 feet of wire is measured out and tied to the other end of the three foot length of nylon. The last 35 feet go to the chimney, by way of the last nylon insulator length.

The middle 35 feet droops down as a loop. The theory behind this is that of a collinear antenna. The antenna currents in the horizontal parts are in phase and add together to increase the power radiated sideways-on to the wire.

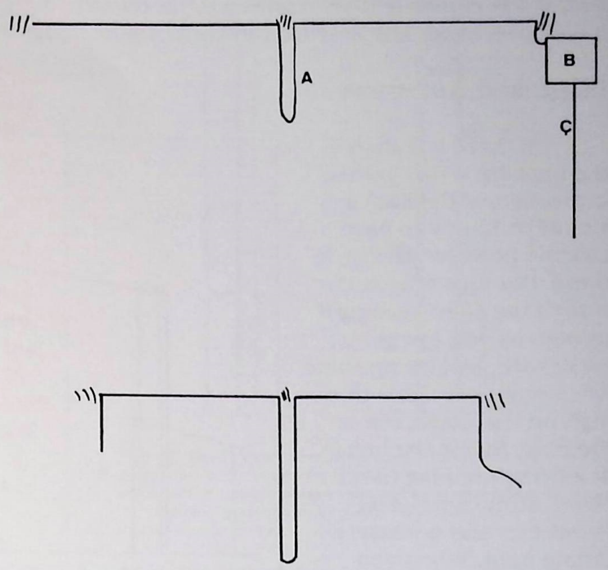

Figure 5 - *G3DLN's invisible collinear antenna. Each element is a half-wave long. The loop (A) is also a half-wave long overall. (B) is a tuner to match the antenna to the coax line (C). Alternatively, the downlead can be twinlead, with the tuner placed in the shack. Figure 5B shows how the antenna can be shortened.*

Del gives a method of shortening this antenna. Let a few feet of wire drop from the tree end of the antenna. That is, tie the wire to the cord about three feet along the wire. Increase the loop lengths by twice this amount (six feet), and drop the chimney end by knotting the wire to the cord by another three feet.

To connect this antenna to the coax directly, make a matching unit with a coil and capacitor. Fit it into a waterproof box and then fit it to the chimney end of the antenna. A 35 foot length of wire attached to the ground end of the coil will act as a counterpoise and remove any chance of the rig giving shocks if the coax happens to be a resonant length.

These antennas can be adjusted with a field strength meter. There is a simple one described later. Tie the sniffer to a long pole, excite the antenna with a watt or two from the transmitter, and explore the loop. If the lengths are just right, and there are no nearby metal objects to upset things, there should be a null (no field strength) at the bottom of the loop. If you do find the null part way up one side, then lengthen that side of the loop and shorten the other by the same amount. This leaves the length of the loop the same as before, but shifts the null down nearer the center. Recheck with the field strength meter.

A random length antenna does not have to be insulated from the ground at its far end. If it is convenient you can run the antenna to a ground point, remembering to keep it well overhead. The antenna tuner will adjust things for use on any wavelength.

Disguised Antennas

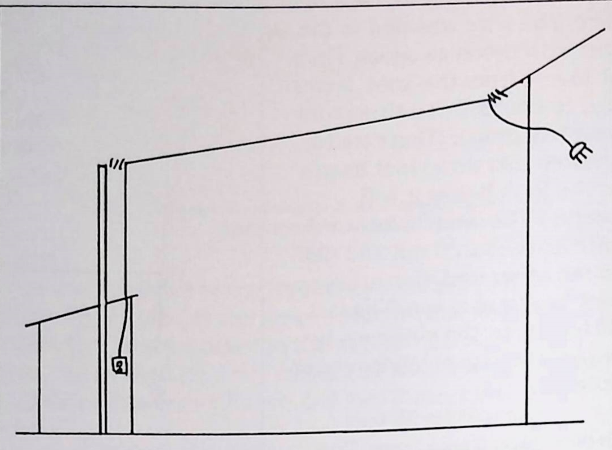

Figure 6 - *The shed in the backyard supports a line that looks like, and indeed can be, a power line. This line can be unplugged from the shack wall socket and clipped to a line to the tuner, when the power line becomes an antenna.*

If there is a shed in the back yard (for gardening tools and the like) it would be handy to have electric power available in there. Put up a pole at the side of the shed, making it as high as you can get away with, and string some exterior power cable from high on the house out to the pole. Inside the house, fit a three-pin plug to the cable, at the shed, and outlet box and perhaps a ceiling light. When you want to work in the shed after dark, or need to use a power drill, insert the three-pin plug into a convenient socket and supply power to the shack. If you want to work DX, unplug the line and connect one of the pins to the antenna tuner, using a cliplead. The neighbors will never know.

N4AQ wanted multiband capacity in an invisible antenna. He bought a Hustler 4-BTV four-band trap vertical and looked for a way to disguise it. He found that thin-walled PVC just fit over the antenna. The top end of the two-inch pipe was fitted with a reducer and a length of 1 & 1/2 inch pipe concealed the thinner top of the antenna. An old toilet ball decorated the top of the flagpole and a three inch bolt secured a pulley an inch or so below.

Another pipe to fit, driven four feet into the ground, served as a base and a five foot copper ground rod completed the construction. Fifty ohm coax was buried to carry the signal to the antenna.

That done, he ran the Stars and Stripes up the antenna and planted a garden around the base. The garden flowers need frequent watering, of course, and doing so also enhances ground conductivity.

If a TV tower is available it can be used as a Marconi antenna on 75 meters, where the quarter-wave is about 67.5 feet. A tower somewhat shorter than this can be resonant if it is top-loaded with a TV antenna. The bottom end should be grounded carefully. It helps to short circuit each pair of sections of the tower at the joints. The bolts holding them together may not make a good electrical contact and this could cause noise as the tower sways in the wind.

Run an insulated wire from the top down the side or through the middle of the tower and to the antenna tuner. Or, the tower can be fed through a gamma match.

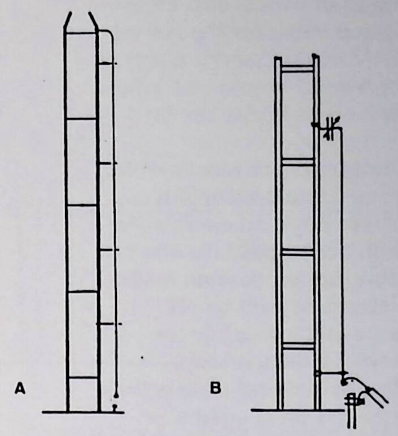

Figure 7 - *The TV tower Marconi antenna. 7A shows the tower connected as a folded monopole, 7B with a gamma match. A 50 foot tower, with the usual extension mast and top-loaded with a TV antenna, is a rough match for the 75-80 meter band.*

A fence around the yard has possibilities. Remember that the antenna will carry voltage, and the higher the power the higher the voltage. For anything over a few watts it becomes dangerous to touch the wire. If the antenna cannot be placed more than eight feet high, use insulated wire and make sure that the end of the wire is well inside the insulation.

A random length antenna can be run all around the yard and nailed to wooden fence posts through the type of insulators sold for use on electric fences. Its purpose can be explained by saying that it triggers an alarm if someone enters the yard without permission. Indeed, if there is an excuse to put up an electric fence, it provides an excellent disguise for an antenna. If not, fit one inch lengths of plastic tubing over invisible wire and affix them to the posts using small staples.

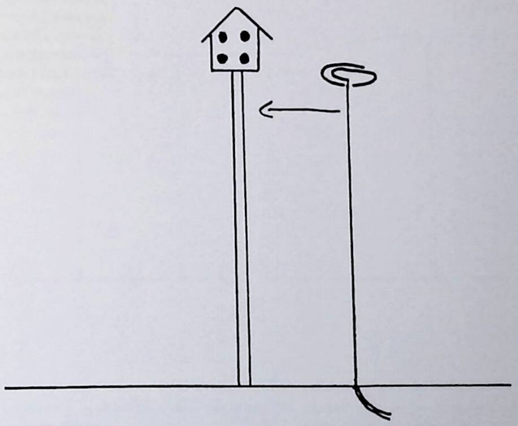

Figure 8 - *The birdhouse disguise. The antenna is set into the supporting pole and top-loaded if necessary by winding the excess wire into a ring inside the birdhouse.*

A birdhouse on a tall pole can be made to radiate at a desired frequency. The antenna wire is worked into the surface of the pole and painted over. It is terminated at the top with an end-loading spiral under the roof of the birdhouse. For

a start, the required quarter-wavelength of wire is cut. Then the length needed for the run up the pole is marked and the rest of the wire wound 'round and 'round a wooden cross inside the bird-house.

Amateurs are most careful about their children's health. What better physical exercise for them than basketball? No one can object to a square column made of four pieces of inch by six wood, screwed into a square section with a finial on top, all carefully painted and a basketball hoop screwed on at a suitable height. A standard basket is 18 inches in diameter and ten feet above the ground.

If the column is 16 feet high - no point in cutting the wood if you don't have to – it can enclose a multiple antenna for 10, 15 and 20 meters. If you can get hold of 20 foot one by six, make the box that length and fit a yard light at the top.

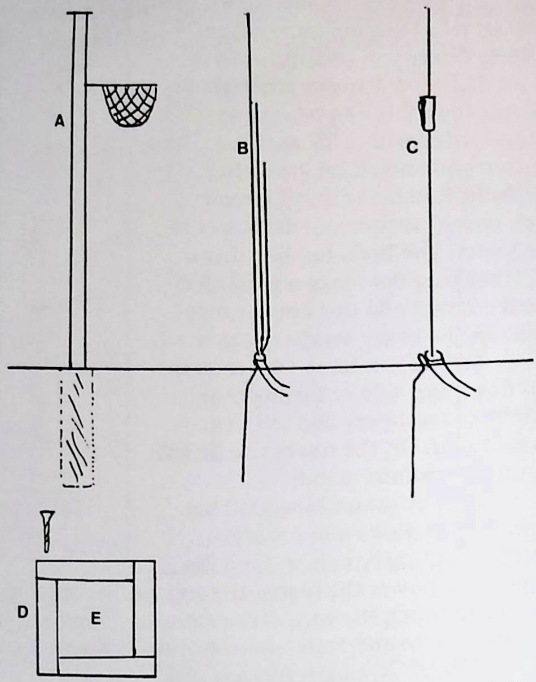

Figure 9 - *The basketball hoop disguise. (A) is what the neighbors see. Inside it is a Marconi antenna. (B) shows three Marconis connected to the same feedpoint. They will be stapled on one side of the box girder. (C) shows a trapped Marconi. The box (E) is made from four pieces of one by six inch lumber (D) screwed together to make the strongbox girder. Use two inch, number eight screws, one every foot along each edge, and drill pilot holes. Paint it with exterior-type paint. This box girder can support a light or a flag. One of the commercial antennas would fit inside (see Chapter 7).*

Many people decorate the outside of their homes at Christmas time with strings of lights on the house. These have to be supported with a strong wire, of course, and with insulators at each end to prevent accidental shock when in use, and also a ground lead, in duplicate for safety, connected in the middle. The ground lead goes to ground via an antenna tuner. Of course, it would be too much trouble to take the supporting wire down every year so it is left up year 'round.

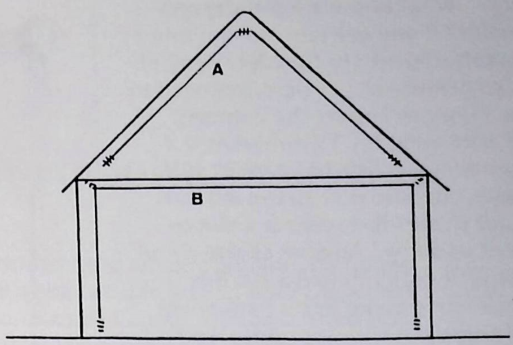

Figure 10 - *Supporting Christmas lights with an antenna. (A) is a dipole under the eaves, useful for an attic or upstairs shack. (B) is a long wire up, along and down the side of the house. This is useful for a basement shack or for a house with a hip roof. However, the antenna may be very difficult to use when the Christmas lights are up.*

A clothesline can be used as an antenna. Again, this depends on the neighborhood. Put one up and if anyone complains you can claim you are saving energy by not using a gas or electric clothes dryer but free, efficient "green" solar power instead. Remember to also use it for drying clothes occasionally! The small alligator clip and fine wire joining it

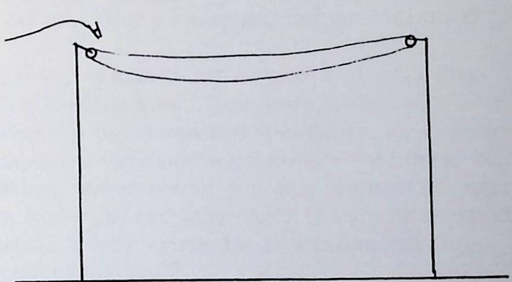

Figure 11 - *The clothesline antenna. Use plastic covered wire to avoid noise from the pulleys. The clip lead must go to bare wire, of course.*

to the antenna tuner are removed when using it as a clothesline.

What about a lightning conductor? If you are just moving into a neighborhood, try this. A tall rod of hard-drawn copper pipe, fastened to the chimney top by the chimney mounts used for TV antennas is grounded, using very heavy cable. Again, the fine wire to the antenna tuner comes indoors via a convenient window. Anyone asking about it is told that you had a terrible experience some years back when lightning struck your house, setting fire to it and causing severe damage. As a result you will never have a home that isn't protected from lightning. Point out that a lightning conductor usually protects several nearby houses, too.

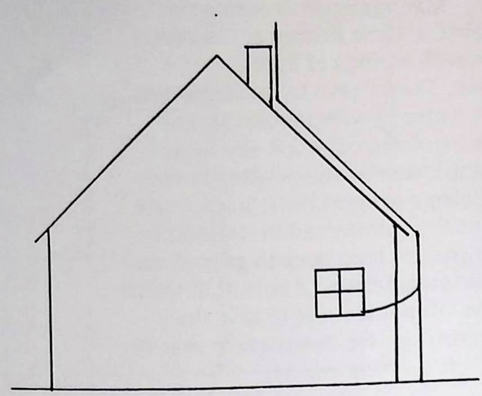

Figure 12 - *The lightning conductor antenna. The lead from the shack window to the lightning conductor*

A drive around town will give you an idea of the strange things people stick up on top of poles. Little wooden men connected to a windmill who "saw wood" when the wind blows. Ducks with wings which whirl around in the breeze. How about an imitation owl to keep the birds out of the garden?

TWO

2

HIGH FREQUENCY INDOOR ANTENNAS

An indoor antenna is completely hidden from anyone outside the house. A low power high frequency HF antenna in an attic can enable you to work the world, though not to break any records. So can an antenna draped about the room. Even your basement can hold an antenna. Naturally, none of these will be as efficient or "get out" as well as a good outdoor antenna, but people have worked all continents with indoor antennas. It's a matter of making the best of what's available.

Be aware of the new "smart houses," which have computer control of everything and wires running everywhere. Often the computer keeps guard on the house, giving a warning if intruders or other unwelcome visitors are about. If not properly designed, a nearby transmitter could activate or inactivate these warning systems, or have other undesirable effects. Worse, a skilled burglar might be able to deliberately deactivate the system, using radio, before entering the house.

Some years ago, when this "smart house" idea was little more than a gleam in the eyes of entrepreneurs, hams pointed out that the electronic environment in which such equipment is expected to work, is filled with signals from radio transmitters of all kinds, from enormously powerful TV and radio stations, through mobile radios in taxis and police cars to CB radios. The equipment manufacturers took the point and designed equipment suited to this environment.

However, there is always someone ready to make a little worse and sell a little cheaper, and those who consider price only are that man's main prey. Somebody, somewhere, is going to save money on interference suppression and spend it on advertising instead. Be sure that you don't get a house in a subdivision where there are homes fitted with substandard electronics. Ensure that any "smart house" you buy is smart enough.

If an indoor antenna is your choice, first of all carefully check the space available to you. Examine the attic. If the roof is metal it might be useable as a broadband antenna. Try it anyway. If not, is there a useable gable end?

Measure the longest stretch of free space where you could put a length of wire in the attic. The wire does not have to be straight, though try to get the central part of it as high and straight as you can. My emergency indoor antenna runs the full length of the ridge - 24 feet - then down the rafters, to bring the full length to 32 feet for 20 meter use.

If your antenna length and available space don't match, zig-zagging the ends of the antenna can absorb the extra wire without losing too much efficiency.

If the roof is "hipped," that is, no wall is carried up to a gable, consider an inverted "V." Two wires go from the center ridge, each down one of the hip rafters, where they are secured. The feedpoint is where the two wires come together at the ridge.

An improvement on this antenna uses four equal length wires from the center of the ridge, one down each of the hips. Make them full length. They are connected together in pairs at the top and fed with TV twinlead there. This has been popular with some of the QRP'ers as an all-band antenna. The wide spaced "V" antenna elements make it broadband.

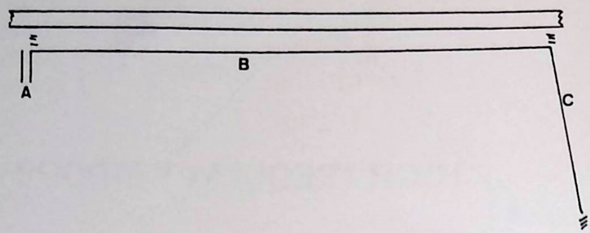

Figure 13 - *What can we put in the attic? (A) is the downlead, (B) and (C) together a half-wave on the most used band. If the half-wave is longer than the ridge pole, run (C) down a rafter.*

Remember that an antenna is only half of the radiating system. The other half is the ground. The electric power lines are ground to RF, so the wires to the lights in the ceiling below are part of the antenna. Keep the antenna as far away from them as possible.

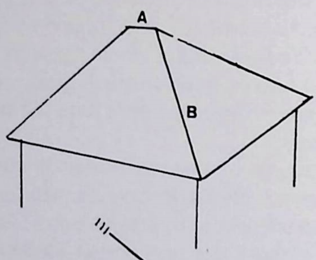

Figure 14 - *A fan dipole in the hip roof attic. Here (A) is the very short ridge, under which the insulator between the antenna elements (B) is supported. The elements run down the hips. They can be run along the eaves if they are overlong.*

Antennas In the Shack

An ordinary house is usually made of wood, brick or stone. Larger buildings are steel framed. It is usually difficult to receive or transmit from a steel framed building and necessary to somehow get the antenna outside.

If the room is unfamiliar, find out if your receiver can pull in signals with a wire antenna. A length of six to 10 feet should do. If this provides good signals you won't have to get an external antenna. If the signals are poor look for a way to get the antenna outside the building. This generally means from a balcony or through an open window. If the windows don't open, use the receiver to find out if the metal window frame is insulated from the steel.

Take a lead from the antenna socket and connect it to the window frame. If the signal from a shortwave transmitter is distinctly better this way than on the 10 foot wire it is worth while trying to use the frame as an antenna.

It may be that a sealed metal window frame is accessible from both inside and out. If so, connect the antenna to the outside of the frame and the tuner to the inside of the frame. Small self-tapping screws will make the connection, but avoid pressing on the glass with the screw.

If the window frame is well painted, tape a length of aluminum foil to it and connect the foil to the antenna lead.
The capacitance between the foil and the frame will transfer the signal to the radio.

An antenna in a room can be draped around the ceiling or around the floor. If the room is yours to do with as you wish, put a screw hood or similar suitable holder-fastener in two or more corners and tie the antenna to them. Otherwise you'll have to use your ingenuity or sticky tape to get the wire up. You could also drape it at floor level, along the base of the walls. The antenna may be along one wall or across the room, diagonally. This gives you a longer horizontal run. Again, the antenna may be extended either down the corners or along the ceiling at right angles to the main run. Indeed, the antenna may be a ring of wire all around the room, cut and fed anywhere with TV twinlead and a tuner.

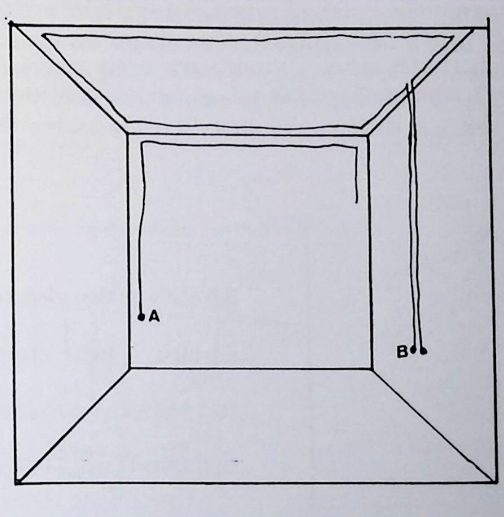

Figure 15 - *In-room antenna possibilities. (A) is the tuner end of a quarter-wave, working against ground (see Figure 37). (B) is a loop antenna on the ceiling, fed through twinlead.*

The sticky, one-side aluminum tape used to seal air ducts, is a useful indoor antenna material.

A basement antenna will also work. If this is a possibility, examine the location carefully. Basements often contain a lot of grounded piping and wiring. Can an antenna be strung at a reasonable distance from all of these grounds? If you're in doubt, try it. Remember to take all precautions against the antenna being touched by someone when it is in use. Even with low power the voltage at the ends of a basement antenna can be high. By the same token, the ends should be well insulated.

Random length vertical antennas go from the tuner up to the ceiling or attic. The wire is strung in a straight line as much as possible and the rest of the wire zig-zagged away from the last straight bit. A counterpoise can be similarly zig-zagged.

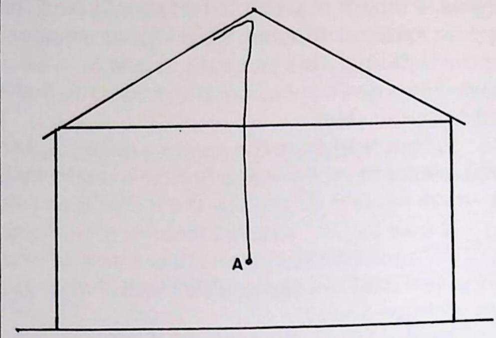

Figure 16 - *It is possible to make a hole in the ceiling of the shack. The vertical antenna of Figure 15 can be extended upwards. Zig-zagging the far end of any antenna can make it fit into smaller spaces.*

A "fat" dipole is much wider than one of wire. It has the advantage that it will change its impedance less with frequency than will a thin dipole. An indoor fat dipole is easy to make, using the widest household aluminum foil you can get. Try for a width of 16 or 18 inches. The lowest frequency covered will depend on the run of space in the room or attic. Here are usable dimensions:

3.5 MHz – two elements 40 ft. each

7.0 MHz – two elements 20 ft. 6 in. each

10.1 MHz – two elements 14 ft. 6 in. each

14.0 MHz – two elements 11 ft. 3 in. each

Adapting a Slinky

The antenna on a two meter handheld is much shorter than a quarter wavelength. The rubber ducky is shortened by winding the antenna into a coil, called a helical antenna. The same technique can be used to shorten a 40 meter antenna to fit into an attic or around a room. This can be done by winding wire around a former, or more easily by buying a couple of "Slinky" toys, securing one end of each to an insulator and feeding them there with coax. Apply a little power and extend the Slinkys until they load the transmitter properly. The total length will be roughly 15 feet. One Slinky cut in half will provide a 20 meter antenna, four - connected two on each side - will resonate on 80.

Balcony Antennas

Many apartments are graced with balconies on which, in the pleasant days of summer, one can relax in a comfortable chair or grow roses or cabbages or set up antennas - visible or hidden.

Balconies have steel railings, which complicate things because the steel will respond to a radio signal, distort the pattern and upset the impedance of a nearby antenna. On the plus side, they can be used as grounds if they are properly welded together. Bad joints can rectify and cause trouble.

A flagpole can be placed on a balcony railing. A 10 foot length of dowel can be secured to the bottom rail and supported at an angle by nonconducting braces secured to the top rail. Naturally this is equipped with a visible pulley and rope, and an antenna of 16 gauge or so wire, set into a saw-kerf along the dowel so that it is invisible. The antenna is coupled to the antenna tuner through a roller coaster or tapped coil so it can cover several bands. The ground connection of the antenna is the steel railing itself. This is similar to a high frequency mobile antenna. Remember to paint the dowel with good exterior paint.

If the railing is well constructed it can be used as an antenna. Just rig a connection to it. A self-tapping screw, into a drilled hole, will serve.

Delicious tomatoes can be grown in pots on balconies or "containers," as the gardeners call them now. Tomatoes come in

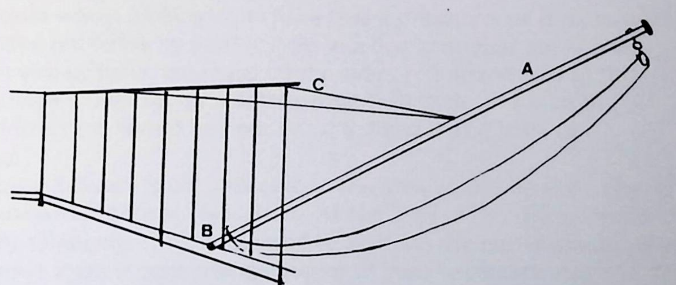

Figure 17 - *The flagpole antenna disguise, mounted on a balcony rail. The pole (A) is fixed to the lower rail at (B), where the necessary fitting can ground the coax, and the braces (C) keep the pole at a convenient angle.*

two kinds - determinate or bush, which stay close to the ground, and indeterminate, which crawl about the place or can be trained to grow up a pole. Naturally, hams prefer the taste of indeterminate tomatoes and will provide them with the necessary stick to climb. The stick will hide an antenna just as successfully.

How can you disguise a ring antenna there? Get some coarse black nylon netting and tie it all around the antenna and use slips of bamboo, like the ribs of an umbrella, to make it look like a TV satellite dish. Put it outboard of the railing or set it up on the ceiling with half of it outboard and hang wind chimes on it.

Does the house have metallic guttering for rain water disposal? If so, screw all the parts of it together solidly, using sheet metal screws, to ensure a good connection between them. Then secure a fine line from any part of it to an invisible downlead. If there are no metal gutters find an excuse to put guttering along one side, with a downspout. You'll have an "L" antenna, ready to use.

THREE

3

THE SMALL OR MAGNETIC ANTENNA

Magnetic antennas are useable indoors or outdoors. They have only been in use by hams in recent years but are becoming popular for their adaptability to difficult circumstances. They are small compared with their wavelength so they deserve a chapter of their own.

"Small" means an antenna that is small compared to its wavelength. Any short wire loop can be tuned to frequency by the use of a tuning capacitor. Such antennas can be used for receiving. However, to use them as transmitting antennas means that allowance must be made for the much higher current flowing around them. Since the near-field of these antennas is mainly magnetic they are often called magnetic antennas.

Magnetic loops are intriguing. They can be far smaller than a wavelength. They must be carefully made, however, and one component - the tuning capacitor - must be of high quality. Nevertheless, anyone who takes the trouble to build a quality unit will have an antenna which, it is claimed, performs better than a dipole at low heights. Since it radiates the near-field magnetic component of the field, a loop is far less affected by absorption of the RF by nearby objects.

As a receiving antenna, where the efficiency is less important, a loop can be the antenna of choice. It is less likely to pick up interference because it responds to the magnetic field, not the electric. Most nearby interference is concentrated in the electric field.

This is truly an antenna worth looking at if space is at a premium, as it usually is in an attic. It can be disguised outdoors by setting it up in a dog kennel or small tool shed. A garage can contain two or three antennas on the sides or horizontally in the roof. But beware! The antennas would be seriously de-tuned when the car is in the garage. A small antenna of this type would be unnoticeable fixed to the back of a wooden chair on a balcony.

A magnetic antenna's efficiency is proportional to the area within its ring. Therefore, the best shape for a magnetic antenna is a circle. As the area of the shape diminishes, so does its efficiency. Octagons (97% compared to a circle) are easily made, using the 135 degree copper elbows from the plumbing counter at your hardware store. Squares (63% compared to a circle) using 90 degree elbows, are often used.

The circumference of the antenna is about 20% of a wavelength. Because of the very high currents flowing in them strict attention must be paid to the conductivity of the joints. That is another reason why a circle, bent from an uncut length of pipe, is preferred.

A magnetic transmitting antenna can be made from copper water pipe an inch in diameter. Some grades of pipe can be filled with sand and bent into a circle. If hard-drawn, and thus unbendable, it is formed into a square or octagon, using copper elbows at the corners and brazed or at least well soldered.

A variable capacitor is fitted at one corner or in the middle of one side. The capacitor has to resist high voltage so the plates are well apart from each other. The edges of the plates should be rounded.

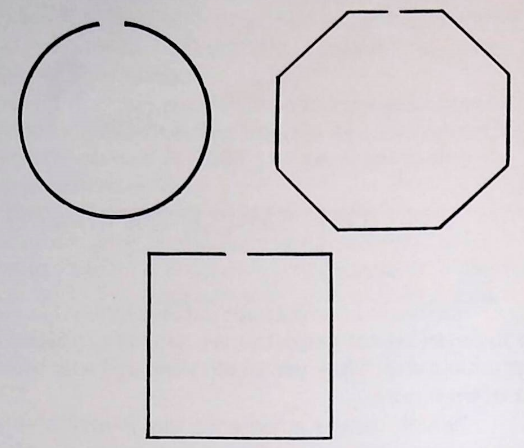

Figure 18 - *The three usual forms of a magnetic antenna. (A) is a circle of soft copper pipe, (B) an octagon of hard-drawn copper pipe with 135 degree sockets, (C) a square, made with 90 degree sockets. The gap at the top of each antenna is the location of the tuning capacitor.*

The signal is transferred to this loop by a small ring of heavy wire inside. Alternatively, the center conductor of the feedline is tapped to one side of the antenna at a point about 10% of the circumference from the feedpoint. Either of these is connected by a length of coax to the transmitter. The assembly is tuned by the loop capacitor. The tuning is extremely sharp.

Here are the details of a magnetic loop for the low bands, built by Robert, I1ARZ. It tunes from 14 to 30 MHz.

A 10 foot length of 7/8 inch or bigger copper pipe is bent into a circle having a diameter of about 40 inches. To do the bending, take a piece of one inch wood or thicker and cut a quarter-circle out of it, to a 40 inch diameter (20 inch radius). Screw this to a four foot square of 3/4 inch plywood. Screw a short piece of the one inch wood close to the quarter-circle as a stop to hold the pipe against the bend.

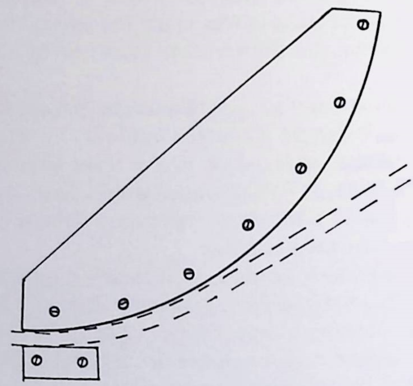

Figure 19 - *The plywood jig needed to bend copper pipe to a circle.*

Fill the pipe with dry sand, tapping it as it is poured in to make sure there are no air spaces left inside, then plug the ends.

Now trap one end of the pipe between the curve and the stop. Slowly and gently bend the pipe to the radius size. Before the pipe is bent the full quarter turn, relieve the pressure and slip the bent part of the pipe through the gap, ready to bend the next section. Keep the pipe flat against the backboard as you do this because the circle must be in one plane.

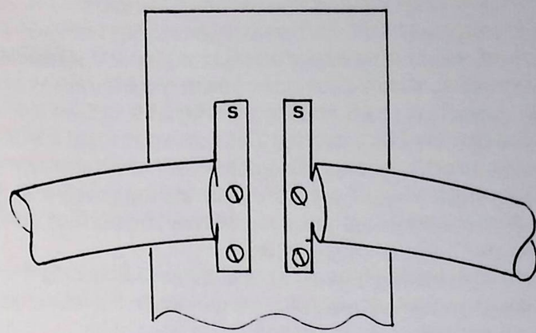

Figure 20 - *The ends of the pipe for any of the three shapes are partly cut through on the circumference, the ears so formed are flattened and used to bolt the pipe to a piece of plexiglas. The capacitor terminals are soldered at position (S).*

The ends of the pipe will now be fairly close together. Empty out the sand. Cut both ends along the length of the pipe for two inches and then to a diameter to leave a short half pipe at each end. This can be flattened to form a surface to which the capacitor can be soldered. The soldering must be well done to keep the resistance of the loop as low as possible. Drill a hole in each flat piece and use machine screws to secure it to a piece of quarter inch plexiglas.

The tuning capacitor must be of good quality. Best is a split-stator capacitor of 120pF per section, with a spacing of 0.03 inches or better. The edges of the vanes of a high-quality capacitor are rounded. Rounded edges do not discharge electrons into the air (corona or "St. Elmo's fire") as readily as sharp edges or points do.

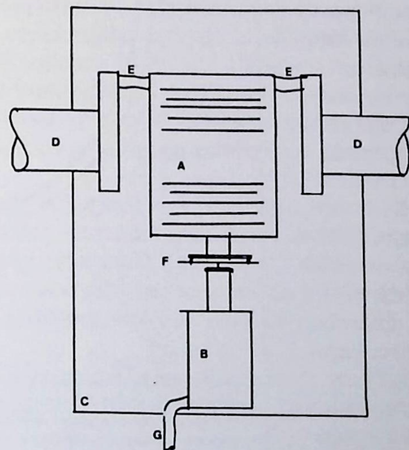

Figure 21 - *The ends of the pipe (D) are soldered to the capacitor (A) terminals at (E). The capacitor is driven by the motor (B) through the universal joint (F). The motor leads (G) are shielded and run straight down the antenna support.*

Each end of the loop is soldered to a stator terminal of the capacitor. The entire capacitor is then equivalent to a 60pF variable capacitor connected across the end of the loop. It is best if tuned by a motor, allowing one's body to be kept away from the loop. The Herbach and Rademan catalog (P.O. Box 122,

Bristol, PA 19007-0122) shows a high torque reversible motor turning at 0.6 rpm on 12 volts. The catalog number is TM92MTR1946.

A low speed and reversibility is essential because the tuning of a small loop is extremely sharp. Fit an insulating coupler between the motor and the capacitor.

If the loop is easily accessible from the shack, the motor can be replaced with a string drive. If you have ever dissected old radios you will know about these. The variable capacitor shaft carries a pulley. A length of cord goes around the pulley and one end of it is tied to a spring. The tuning control knob, which may be several feet away, carries another pulley. The cord goes around this and is tied to the other end of the spring, tightly enough to keep the spring extended. A pointer is fixed to the cord near the control knob. As the cord moves the pointer passes across a paper scale, marked to show the band tuning positions.

The tuning capacitor and its motor are bolted in place on the plexiglas. The plexiglas itself is supported on a mast (on a broomstick, for indoor use), being held on by pipe clamps, as is the loop. The motor feedline is of twin screened cable of the kind used in audio amplifiers. It is dressed down the mast and away.

RF energy is coupled into the loop by a secondary coupling loop. A single turn of heavy wire would do for transmitting, but it is usual to use a Faraday screen to make the antenna work better when receiving. This is a single turn of RG8 or RG13 coax, one-fifth to one-eighth of the main loop diameter, formed into a Faraday screen. The coax is formed into a loop of the chosen diameter and the vinyl cover is stripped from the

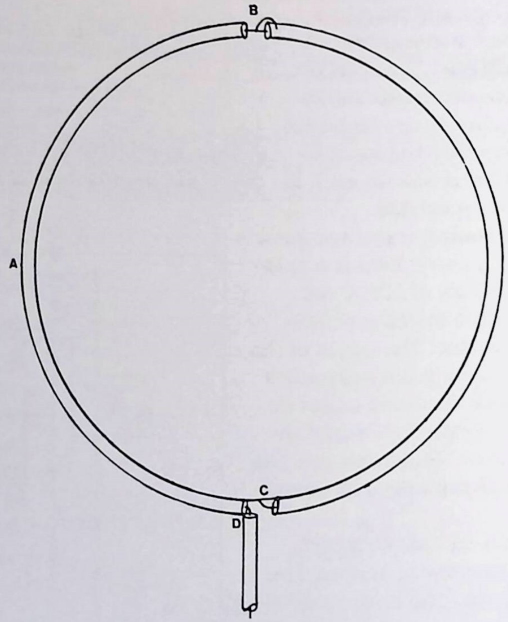

Figure 22 - *The shielded loop (A) to transfer the signal to and from the antenna. The loop is made from the end of the coax feedline. Measure off the length of line needed for the loop. At (D) the coax is sharply bent to start the loop, and the shield braid is exposed. The loop is cut half way around and the shielding is cut. The insulation is stripped from the inner conductor there, enough for a short lead to be soldered there and to the shield as shown. The coax continues around to (C), where the inner conductor is shorted to the shield and the inner conductor at (D). This loop is set up exactly in the plane of the main loop, opposite the capacitor, and can be moved slightly up and down to find the best SWR.*

end, and from where the end meets the feedline. They overlap about a half inch. Here the end inner conductor, the end screen braid and the braid near the feedline are all soldered together (see Figure 22).

Half-way around, cut off an inch of vinyl cover, cut the braid all the way around, strip the insulation from the inner conductor and solder it to only one side of the braid. The other side of the braid is trimmed back slightly to avoid shorts. The joint is bound with insulating tape. The feed end of the coax is fitted with a connector.

The loop is fixed to the mast by four hose clamps. At the top and bottom of the loop, one clamp that will fit the mast holds another one at right angles to fit the coax. The coupling loop is set exactly in the plane of the main loop. The feedline and the motor line must run down the mast three feet down from the loop to avoid unneeded coupling.

Set up a ground plane underneath the loop when it is in its final position. It need not be connected to the loop. A cross of household aluminum foil will do, as long as it will fit. If the loop is hidden away in a garage or garden shed, the ground is already there. Excite the loop at 18 MHz if you can, or else at 21 MHz, using the smallest amount of power that will move the SWR meter. Tune the loop capacitor for lowest SWR.

Now move the coupling loop up and down the mast inch by inch to see if the SWR can be improved. Keep the loops in the same plane. The size of the coupling loop can change the SWR too, so, if necessary, make another loop of a different diameter. I1ARZ found a loop two inches greater in diameter than that theoretically called for worked best for him.

The loop radiates in a figure eight pattern off the ends of the diameter of the loop, horizontally if the axis of the loop is vertical. If there is room the loop can be set up with a rotator to direct the signal in a chosen direction (actually two directions, on opposite sides of the loop). If headroom does not allow all of the seven feet needed to set the loop upright, it can be set sideways but, of course, then the rotation is not of much use.

If your interests are for even longer wavelengths and you have room for a bigger loop, I1ARZ has designed and built a square loop for 40, 80 and 160 meters, using the same plan. The sides are eight feet long. The material is 1 & 1/2 inch diameter light copper pipe. This is formed into a square with four copper elbows soldered (brazed is better) for highest conductivity. The job is done on a flat concrete floor to keep the elements in one plane.

The top of the square is sawn through at the half way point and connected there to a 7 to 1,000pF variable capacitor (preferably vacuum type). Again, be most careful to make good, high-conductivity joints. The capacitor must be rated at 7 kV for powers of 100 watts. Such a unit is expensive, but it is quite possible to make an air-spaced one from aluminum sheet, threaded rod, and plexiglas endplates. An 8 kV capacitor has 1/4 inch spaces between its plates.

The coupling loop is 20 inches in diameter, made as a Faraday screen, as above. Adjustment and feeding are the same, and naturally it is tuned on 40 meters. the bandwidth is narrow, especially on 160 meters.

Instead of coupling a loop, a coupling rod may be used. Very carefully solder the ground electrode of a coax connector to the inner conductor and take it along the loop for one-tenth of the circumference and solder it there. Adjust the spacing of this wire to get the lowest SWR.

Building and using a loop for use on only one band is worth consideration. The loop should be a little less than a quarter-wavelength in circumference. Since the tuning range is much smaller, good quality fixed capacitors can be used instead of a large capacity variable type. Use the best variable capacitor available to find the capacity needed at low power, and assemble fixed capacitors to give the same value. Or, cut a piece of RG8 to length. It has 100pF per meter. Two-sided copper-clad printed circuit board is another possibility. Measure the capacity of a full-sized piece of board and cut off what's needed to give the capacity you want.

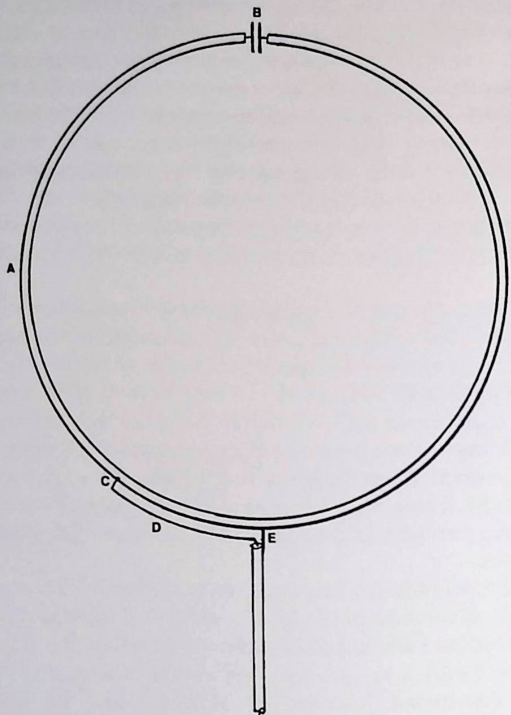

Figure 23 - *An alternative to the shielded loop. The coax feedline ends at (E). The outer braid is shorted to the loop at (E), exactly opposite the capacitor. The inner conductor is soldered to a length of heavy gauge wire, which is bent to follow the curve of the loop to the point (C), 10% of the circumference of the loop from (E), and soldered there. The spacing between the loop may be altered slightly to get the best SWR.*

Monoband Loop Dimensions

MHz	1.9	3.6	3.9	7.1	14.1	14.3	18	21	28.5
Side of sq. in meters	9	4.8	4.4	2.4	1.3	1.2	.95	.82	.6
inches	360	190	176	95	52	48	38	33	24
Diameter of circle in meters	11.5	6.1	5.6	3.0	1.8	1.5	1.2	1.0	.76
inches	460	244	224	120	72	60	48	40	30

Soldering copper pipe is a heavier job than most soldering work an amateur radio operator needs to do. A propane torch, flux-cored heavy gauge solder (this is sold for the purpose), medium sandpaper and a pair of heavy leather gloves are essential. Start by cleaning the end of the pipe or the inside of the elbow with sandpaper. Use a length of dowel to get the sandpaper right inside the elbow.

It is a good idea to make a jig of one by three inch lumber to hold the pipe in position when soldering. A "V" block at each end of a length of lumber rather shorter than the pipe to be used serves the purpose well.

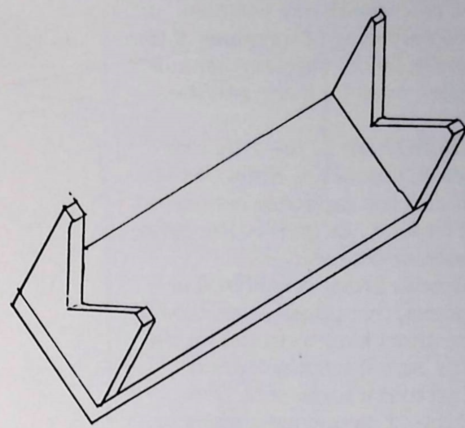

Figure 24 - *A jig to hold pipe steady when soldering it.*

Four meters or 13 feet of one inch pipe are needed for a 10 to 20 meter loop, along with four 90 degree elbows. This square loop will have sides 40 inches long. It is assembled and soldered, and one side is cut half way with a pipe cutter, taking out the short length of pipe to make space for the tuning capacitor. The ends are tinned and shaped as needed to fit the capacitor terminals.

First, cut the pipe to length. Then tin the cleaned ends. Tinning is the process of coating the copper with solder so that there won't be any unsoldered spots in the joint. Put on your gloves, lay the pipe in the jig and heat the cleaned end until the flame shows the slightest trace of green. Then remove the flame and touch the solder to the end. It should melt and spread neatly. Turn the pipe in the jig steadily to spread the solder evenly, adding more as needed. Do not heat and apply solder at the same time.

Leave the pipe. To tin the free end stick a spare bit of pipe in the bench vise and put the elbow on it. Heat this end in the flame and when the elbow is hot enough, melt some solder inside it. Then take the pipe out of the vise. Holding it in your gloved hand, turn the elbow so that the melted solder covers the inside. Reheat as needed.

Go back to the jib and heat the end of the pipe again until the solder melts. Keep the elbow in the flame, too. When all the solder is melted, put the elbow over the pipe end and turn the pipe to make sure the solder is evenly distributed. Reheat the joint and touch the point where the elbow ends with solder wire. Solder will be sucked into the joint. Now leave the assembly to cool.

Solder one elbow on each pipe. Then tin an end of one pipe and the elbow of another, and solder them together. Now there is an assembly of pipe-elbow-pipe-elbow. Make another. Prepare the free ends of each pair by tinning them. Tin the open elbows, put the assembly on a clean concrete floor and solder them together. This ensures that

the two sub-assemblies are flat. If the antenna is a square this will complete the soldering of the pipes. If the assembly is an octagon, further sub-assemblies must be made and finished flat.

If the shape of the attic roof demands it, one of the elbows can be omitted and the capacitor connected there. The feed line goes to the opposite elbow, of course.

A coax fitting is soldered to the pipe exactly opposite this cutout. Take the short length cut out for the capacitor, saw it lengthwise and open it so that it forms a "J." The hook of the "J" is opened slightly to fit snugly over the pipe. The stem of the "J" is drilled to fit the coax connector. The unit is then soldered into position.

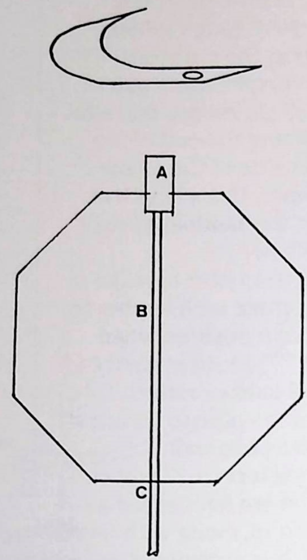

Figure 25A - *A short length of tube can be cut and opened out to form a "J" shape, drilled to fit the feed loop coax connector and then soldered to the main loop. Figure 25B - The general set up of a loop: capacitor (A) and supporting rod (B). The feed loop is secured at (C).*

A length of broomstick will serve as an upright. The capacitor is bolted to a sheet of plexiglas, which is, itself, bolted in position on the stick using U-bolts. The loop is then put in position and the top end fixed to the stick with two pipe clamps. The other end is soldered to the capacitor terminals.

The coupling loop is then made. This is a ring of coax, set up as a Faraday screen (see Figure 21). Alternatively, the coupling can be by a length of heavy wire or 1/4 inch soft copper pipe, soldered to the coax connector and to the ring (see Figure 23).

A garden, said the poet, is a lovesome thing. One delight in a garden is an arbor, what some call a pergola. This is a wooden archway, at least eight feet tall, and as wide as you wish, that plants and flowers can grow on. Erect one close to the shack and strengthen it with a ring antenna or two!

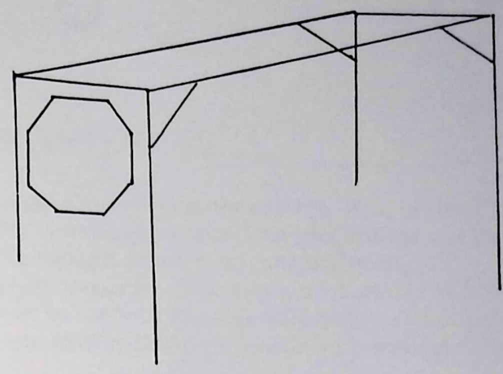

Figure 26 - *A pergola, or arbor, showing one possible position for a magnetic loop.*

Large diameter copper tubing is hard to bend, and probably expensive. G3PTN got around this by making the antenna out of two squares of RG8U coax, spaced three inches from each other. The square has eight foot sides. Inners and outers of the coax are soldered together at each pair of ends, and to the capacitor. This performs like a square of three inch diameter copper tubing with no soldered joints at the corners.

G3TWE modified this design slightly. He put in another pair of spreaders to turn the square into an octagon, which has higher efficiency than a square, though less so than a circle. He put the tuning capacitor at the bottom of the loop, the logical location since it is the heavier part. The coupling loop was two loops of coax, 36 inches in diameter and one inch apart. They were soldered screen to inner conductor and screened by pushing a bit of rubber hose over them, and wrapping it with aluminium foil.

He notes that the Faraday shield usually recommended is only of use for receiving. However, most people use the antenna for both receiving and transmitting anyway.

FOUR

4

VHF ANTENNAS

There are two meter repeaters everywhere these days. Most of these can be worked with a simple "rubber ducky" antenna from locations that are not too far away. If you want more than local QSOs though, a better antenna is a must.

Some of the methods of hiding high frequency antennas are adaptable to VHF. The longwire antennas mentioned below can be made of invisible wire and run from the shack window to a tree. The flagpole and similar disguises can shield a vertical dipole from prying eyes.

Here are some suggestions for VHF - and UHF - antennas for use if you cannot put up an undisguised outdoor antenna without inviting trouble.

While the horizontal polarization of a TV antenna may be troublesome, the easiest solution to the inconspicuous VHF antenna problem is a tower with a TV antenna on top, which, being broadband, will accept and radiate just about any VHF signal. Whether or not this can be done depends on the legal shackles affecting your location. Check them! The authorities may think that everyone has cable now, and if you intend to put up a TV antenna you could be trying to cheat the cable company.

If towers are frowned on, what about the attic? A TV antenna is probably too big to rotate there, but small three or four element beams can be set up, pointing in the desired directions. They are easy and cheap to make, especially since they don't have to be weatherproof.

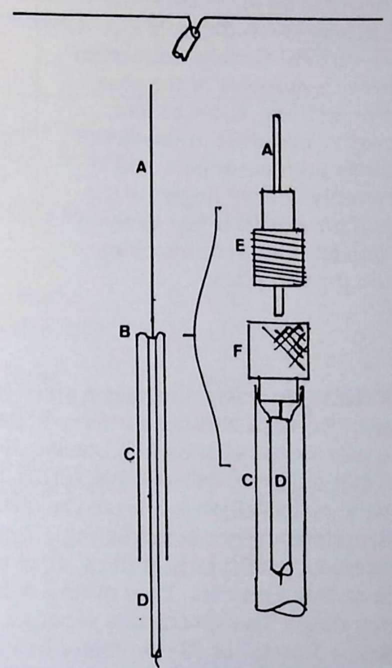

Figure 27 - *Two ways of making a dipole. Figure A shows the elements connected, one to the braid, the other to the inner conductor of a coax downlead. (B) shows a dipole in which the coax shield is connected to a pipe element. This is an excellent form of vertical antenna because the pipe can be used as a support.*

VHF Antenna Designs

The simplest VHF antenna for indoor use is a dipole. This is easily made from two lengths of copper wire. Cut them to length and solder to a coax connector. Or use a length of pipe as one element shielding the wire.

The dipole can be stapled to the ridge or a rafter, either horizontally or vertically. If it is to be used to work mobiles or repeaters, it should be installed vertically for vertical polarization. If it doesn't work well like this, perhaps the wiring in the ceiling below is causing changes in the pattern and some experimenting may be needed to find the best position for the antenna.

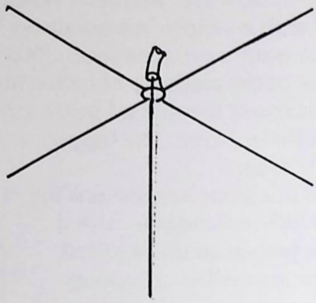

Figure 28 - *The ground plane antenna. A quarter-wave vertical element is connected to the inner conductor and a counterpoise of four quarter-waves at right angles is connected to the shielding braid. In practice, the antenna is built on a SO-239 connector.*

Another good design is the ground plane. The radiator is a quarter-wave vertical element connected to the inner conductor of the coax connector and two, three or four quarter-wave elements are soldered to the outer conductor part, and spread evenly at right angles to the radiator. This design is less likely to have a pattern distorted by wiring below the ground plane.

Yagis

If the radio wave must take a difficult path, making it hard for your signal to hit a repeater or perhaps another station you particularly want to talk to, a dipole may be made to aim more radiation in a specific direction through the use of reflectors or directors. Such dipoles are called *Yagis*. A Yagi, made to a correct design, may double or triple the signal strength in a preferred direction (but at the expense of signal strength in other directions). When constructing a Yagi care should be taken to follow the dimensions carefully, particularly at the shorter wavelengths. Consider the allowances needed for thick or thin elements. They make a difference. Yagis are useful only over a restricted frequency range. This means that separate Yagi antennas must be used for each of the two meter, 1.3 meter or 70 centimeter bands. The simplest Yagi has two elements.

The elements may be the driven element (the one connected to the transmitter) and reflector, or driven element and director. Reflectors are a little longer and directors are a little shorter than the driven elements.

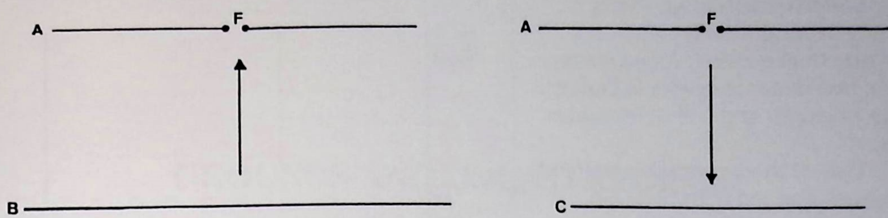

Figure 29A - *There are two ways of arranging a two element yagi. In Figure A, (F) is the feedpoint, (A) the driven element and (B), which is about 5% longer than the driven element, acts as a reflector. The arrow shows the direction of transmission. Reception is from the point to which the transmission is directed. Figure B shows the other way of setting up a Yagi. (F) and (A) are the same as in Figure 29A, but (C), about 5% shorter than (A), is called a director and the signal transmitted goes in the direction of the arrow. Reception is from the point to which the transmission is directed.*

Three or more element Yagis are common. They consist of a reflector, driven element and one or more directors. Designs for really long ones, with a dozen elements or so, are available for those who have the necessary space for them. Here are the dimensions for Yagis up to five elements:

Dimensions of Yagi Elements
Dimensions - meters (inches)

	146 MHz	222.5 MHz	435 MHz
Length of:			
reflector	1.02 (40)	0.664 (26 & 1/8)	0.34 (13 & 3/8)
driven element	0.96 (38)	0.635 (24 & 7/8)	0.326 (12 & 1/8)
first director	0.92 (36)	0.60 (23 & 5/8)	0.31 (12 & 1/8)
second director	0.91 (35 & 3/4)	0.595 (23 & 3/8)	0.305 (12)
third director	0.89 (35)	0.585 (23)	0.301 (11 & 7/8)
element spacing	0.40 (16)	0.27 (10 & 5/8)	0.135 (5 & 3/8)

Longwire antennas - "long" meaning several wavelengths - are quite practical for VHF. A two wavelength, two meter longwire is under 15 feet in length and will fit into most attics.

Two of these, set at an angle of 70 degrees and fed with twinlead, form an excellent longwire antenna, usable by those with sufficient attic space. Erected out in the open and away from disturbances caused by metal, the antenna receives and radiates best along its axis. Notice that the second longwire substitutes for the quarter-wave "balance" element in Figure 31.

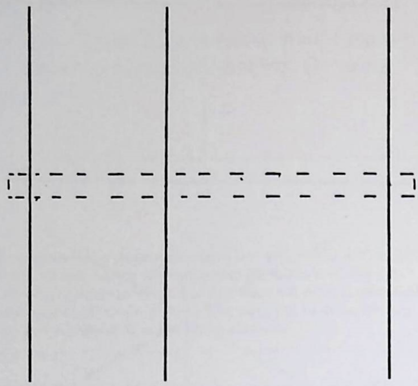

Figure 30 - *A three element Yagi. The element lengths and spacings are approximately to scale.*

These longwire antennas need a two meter antenna tuner to couple the feedline to the transceiver's 50 ohm output.

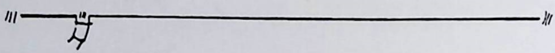

Figure 31 - *A longwire antenna. (A) is one quarter wave long, (B) is two wavelengths.*

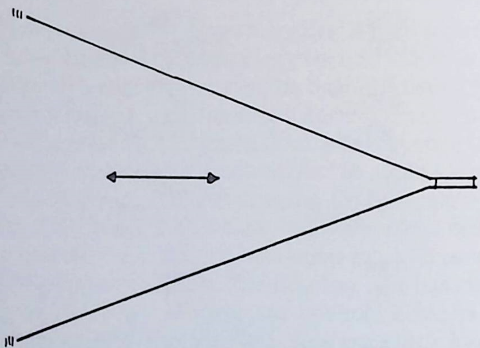

Figure 32 - *A longwire beam. Signals are transmitted or received in both directions along the arrow.*

FIVE

5

GROUNDS AND COUNTERPOISES

Every antenna works against ground. Every transmitter should be grounded for RF. For safety's sake it must be grounded electrically through the power line too, for then the fuse will blow if there is an electrical fault. But do not rely on the power line ground for RF. Without a separate RF ground your signal may be injected into the house wiring or the transmitter case may be "hot" with RF, a fact you will discover if you touch it.

From our point of view, grounds are either the true ground of a sound electrical connection to the planet by way of a conductor stuck into it, or virtual grounds, often called counterpoises. The ground rod is usually the best means, although a metal water pipe coming into the house from its trench in the ground is just as good. Unfortunately, nowadays, iron water pipes are screwed together with teflon tape between the threads and so they cannot be relied upon as conductors.

Do not use the power supply or telephone grounds for any radio work. An entirely separate ground is mandatory.

The ground rod in the garden can be a length of copper or iron or steel pipe, five feet long or so, driven right in. Enough of it should stick out of the ground to take a pipe clamp holding the heavy braid grounding conductor, which then goes directly into the shack. Keep this lead short. Remember that a quarter-wave of wire, grounded at the end, and going to an upstairs window, makes an excellent antenna. The ground rods can be scrap pipe or those available from radio supply stores.

How well the pipe ground works depends on the conductivity of the soil and its moisture content. The one can be helped by burying salt around the pipe, the other by the use of a hose. And talking of hoses, one of those buried, permanent lawn watering systems can be a useful ground. Bury heavy copper wire along with the buried pipe and run the end into the shack.

While the ground rod stuck in the garden can be close to ideal, don't despair if you cannot use one. There are several ways to overcome the problem. Don't try to do without a ground if you can't get to the garden.

Take a look at the water piping system. If it is made of iron, find the telephone or power line ground and measure the AC resistance of the water pipe to that ground. If this resistance is low the pipe is stable. How do you measure the AC resistance? Rig a bridge circuit and measure the AC across it.

In the figure, R1 = R2. 100 ohms each would be suitable. R3 is variable, 0-20 to 0-100 ohms. R4 is the resistance between the two grounds, (M) is an AC voltmeter. The

nearest multimeter range should do. Apply low voltage AC as shown, and watch the meter as R3 is varied. When the voltage measured is zero, then R3 = R4. Remove the current, isolate R3 and measure its resistance. This is the resistance between the two grounds.

If the resistance of the water pipe to ground is high, it means that the pipes are teflon insulated at the joints and therefore are not a useable ground.

A hot water heating system which uses soldered copper pipes is excellent. Even if it is not well connected to the literal ground it has a large capacity and will work well.

If you are in a steel-framed building, the disadvantage of needing an external antenna is partly balanced by the availability of the building's frame as a ground. Drill into it, fit a self-tapping screw, and there you are.

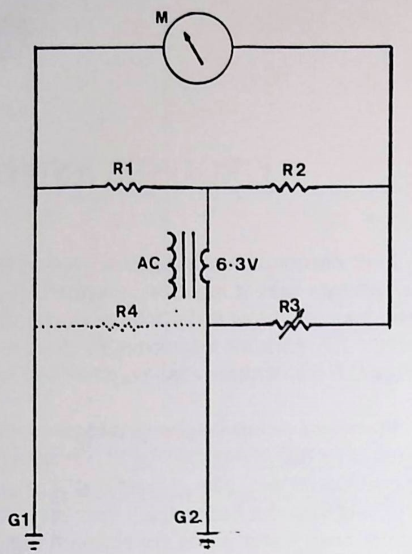

Figure 33 - *How to find out if one ground is better than another.*

Counterpoises

Take an antenna a half-wave long and feed it exactly in the middle. This arrangement acts as two quarter-wave antennas fed in opposite phase, the fields of which cancel out, so it gives no radiation. In practice, the nearness of other objects usually unbalances the antenna and some radiation occurs, but the statement is true for an antenna in free space.

Connect this antenna, stretched horizontally, to the shielding braid of a coax line, and connect a quarter-wave antenna, set vertically, to the coax inner conductor.

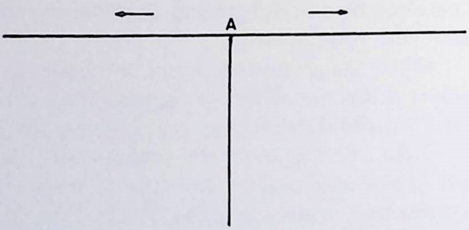

Figure 34 - *A counterpoise. If a signal is applied at (A) to the two equal elements in horizontal opposition, no signal is radiated from the horizontal elements.*

The quarter-wave antenna, being unbalanced, will radiate. The half-wave, center connected, will not, and will act as a virtual ground. If, instead of one half-wave antenna, two are connected to the braid and set at right angles, the assembly is called a ground plane antenna, well known and efficient. It is sketched in Figure 28.

The ground plane is the best known form of counterpoise. Counterpoises were tried a long time ago but were little used until the expansion in radio usage brought them back. Some people believe that medium wave vertical antennas could have been grounded with a ground plane more cheaply than what was usually done - burying miles of heavy wire around tower bases.

If you are confined to a room where no true ground is available, cut four pieces of wire to a quarter-wavelength on the band to be used, solder them together at one end and spread them separately about the room as far as possible. They can go under the carpet. Connect them to the ground terminal of the transmitter with as short a wire as possible.

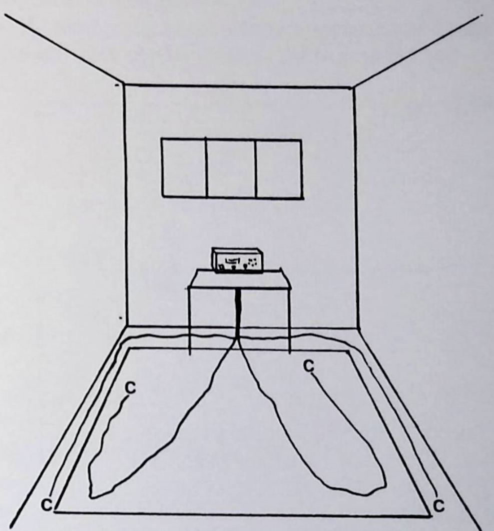

Figure 35 - *A counterpoise ground in a room. The ends of the counterpoises are marked "C."*

This ground can be made for multiband use by connecting wires of different lengths together. Suppose you want to work 10 and 20 meters. Cut four wires to one-quarter wavelength for each band, that is, 2 & 1/2 and five meters (about eight feet and 16 feet). Solder one end of each to a short, heavy wire to connect to the transceiver, and spread the wires out about the floor as best you can - under the carpet if there is one. Just separate them as much as possible, they need not be straight.

This can be extended to three or even more of the ham bands by using quarter-wavelength wires for each band. Note that the ends of these counterpoises are at voltage nodes, another reason to avoid high power. If there are children around make sure they cannot touch them if they crawl around in the shack.

"Four" is no magic for counterpoises. The counterpoise removes the RF voltage from the transmitter and puts it on the counterpoise ends. However, the more counterpoise wires, the lower the voltage at the ends.

SIX

6

ANTENNA TUNERS

Strictly speaking, an antenna is not "tuned." The "antenna tuner" is a matching device, a sort of electronic gearshift.

The simplest antenna tuner is just a coil and a capacitor.
The coil is in series between the 50 ohm coax from the transmitter and the antenna. The capacitor connects to the antenna end of the coil and ground.

Incidentally, an antenna tuner should always be connected directly to the station ground by as short a braid as possible. Do not rely on the coax braid to ground the tuner.

If the antenna is to be tuned to several bands, both coil and capacitor must be variable. The capacitor should be 350pF for 3-30 MHz antennas. These days you can find them more easily in an old radio than in a radio shop. Such capacitors can be used for low power. High power demands wide plate spacing, to avoid sparkover when the voltage across the capacitors is high.

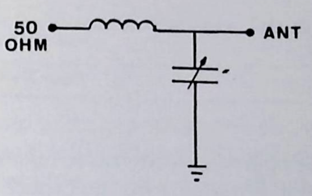

Figure 36 - *Schematic diagram of an "L" tuner, suitable for single wire antennas.*

The coil is either an expensive "roller coaster," a ceramic former carrying the coil, and a contact wheel running along the wire or a switched coil made by the experimenter. This is easy to do. One of the strong paper cores from a package of household wrap will serve as a former. On this, wind a coil of 80 evenly spaced turns of 18 to 24 gauge wire. The first ten turns of the coil are tapped, and each tenth turn thereafter.

The 10 close turns are brought out to a rotary switch (Radio Shack part number 275-1385). Call this the fine tap - and every tenth turn brought out to another, called the coarse tap.

To match the 50 ohms from the transmitter to the unknown impedance of the antenna, first put the capacitor to about half capacity. Then apply power from the transmitter, increasing it slowly until a perceptible reading is seen on the SWR meter. Now

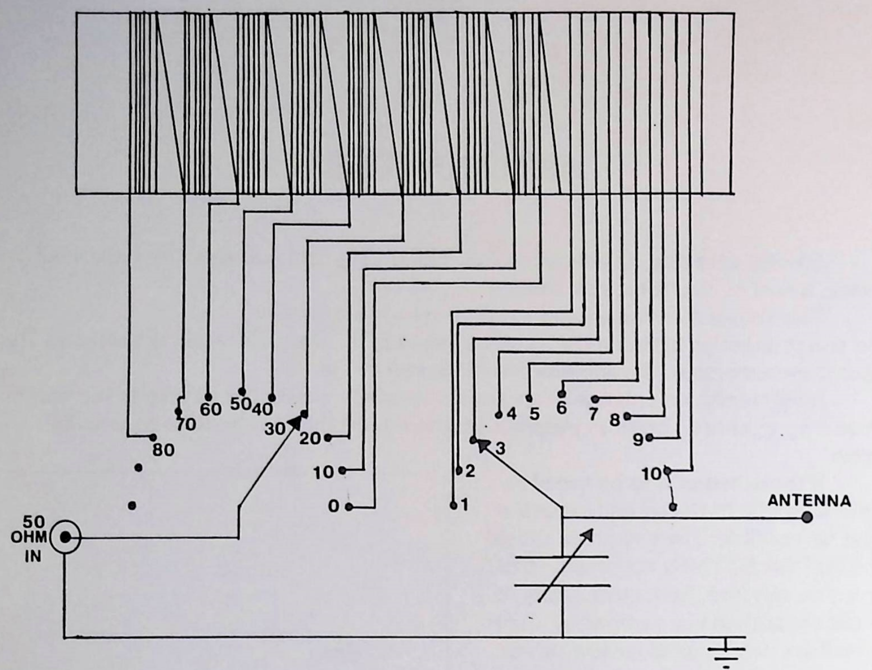

Figure 37 - *A practical, home-built "L" tuner.*

switch the coarse coil control to minimum, and turn the fine control step by step, watching the SWR. If it dips, turn the capacitor to increase the dip. Increasing the power slowly as you work, continue adjusting the capacitor, and try changing one turn on either side of the coil tap, until the dip is a minimum, meanwhile increasing the power. An SWR well below 1.5 is easily obtained with most antennas.

If no null is found with the coarse coil tap at zero, try it at one and vary the fine tap. Then, if needed, coarse two, and so on until a null is found. Now write the positions of the three controls in your logbook so that band changing can be done without further fiddling. Often a band can be covered by changing just the capacitor.

This "L" tuner (so called because of the configuration of the coil and capacitor) is all that is needed for single-ended random length antennas. It will not do for balanced antennas. For them, a z match is the best way to go.

This z match is from Australia. ZL3QQ, VK3AFW and VK3OM designed and built several of them. The diagram shows the construction of one for 3-30 MHz. The main coil is wound on a scrap piece of plastic water pipe of about two inches outside diameter and four inches in length.

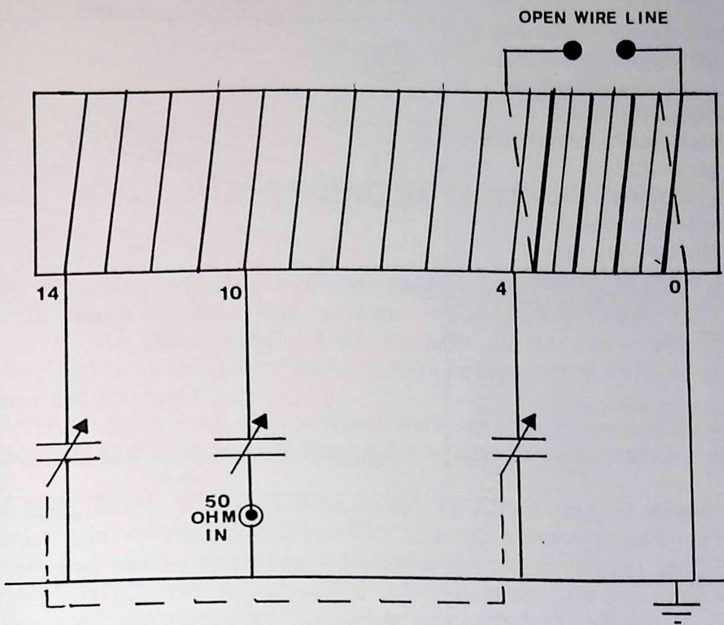

Figure 38 - *The z match. A 24 turn coil is tapped at 0, 4, 10 and 14 turns. The capacitors are 200pF or near. The dotted line indicates the capacitors are on the same shaft.*

Wire from 14 to 18 gauge is suitable. Drill holes in the pipe to secure the wire. Lay two or three lengths of double-sided sticky tape (the thick kind) to hold the coil in place. Wind the wire for the main coil on a length of smaller pipe, about 1 & 1/2 inches in diameter. It will spring out to nearly two inches in diameter and fit easily on the former. The 14 turns should be spread to cover three inches.

The output coupling coil is wound on a short length of 2 & 1/4 inch inside diameter plastic pipe. This is slipped over the ground end of the main coil. Alternatively, it can be wound in between the first four turns of the main coil, using insulation to make sure that the turns don't short-circuit.

Tuning capacitors taken from an old tube radio are ideal for the power levels usable with an indoor antenna. Above about 100 watts, capacitors with wide plate spacing are needed to cope with the higher voltages involved. Vernier drives are recommended.

The tuner can be built on a wooden baseboard, with a metal front panel to avoid hand capacity effects. Thin plywood or Masonite may be used for the front panel if it is covered on the inside with aluminum foil. This should be grounded to the tuner, probably by the capacitors.

Keep the connections between the coil and the two-gang capacitor as short as you can. Do not rely on the coax shield for grounding. Ground the circuit with a heavy wire to the station ground.

The diagram shows the output coil for a balanced antenna. If a longwire or a Marconi antenna is used, one terminal of the ground should be grounded and the other put to the antenna.

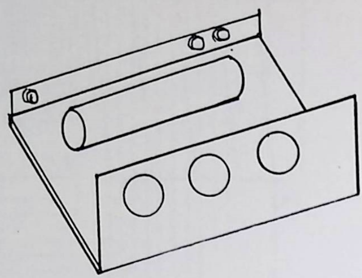

Figure 39 - *A simple wood or metal chassis holds the antenna tuner.*

Field Strength Meters

Use a field strength meter to check the efficiency and the pattern of any antenna. It can also be used as a "sniffer," that is, to find places where there is radiation, whether wanted or unwanted. The design specifies a meter but there is no reason why the low milliamp scale of a multimeter should not be used instead.

A field strength meter can be tuned or untuned. The untuned one is the simplest.

A small metal case is fitted with an RCA phono plug to take the antenna. Inside, the RF felt by the antenna is rectified by the diode, then grounded by the capacitor. The DC remaining is read by a microammeter. A few inches of stiff wire for an antenna will give good readings close to an antenna which is radiating a few watts.

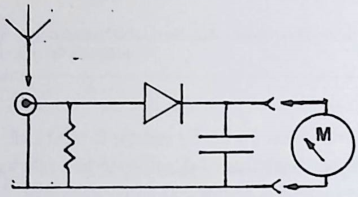

Figure 40 - *A simple field strength meter. The antenna is a short length of stiff wire, plugged into a phono socket. The resister is of 50 to 100 ohms. Any high frequency signal diode will do. The capacitor is 0.01fF. (M), the meter, is best if it is an FET voltmeter, next best would be a 20,000 ohm/volt multimeter on its lowest current range. The field strength meter is built in a small metal box, about 3/4 inches square and two inches long – the kind used to shield IF coils with.*

SEVEN

7

SUITABLE COMMERCIAL ANTENNAS

While the advertisements in amateur radio magazines mostly seem to feature highly visible, mouth watering beam antennas, useful ideas for hidden and invisible antennas can also be found in these. There are antennas that can be disguised, small antennas that can travel anywhere and suppliers of useful parts for building antennas. Several firms sell antenna tuners.

All these suppliers will send you their catalogs and can provide knowledgeable answers to your questions. Most of them seem to have hams on staff who are happy to be of help.

The Radio Works (Box 6159, Portsmouth, VA 23703) has a lot of interesting stuff. They supply the InTreeVert(c) VHF and UHF antennas that you mount in a tree by tossing a rope over a branch and pulling the antenna up, where they are nearly invisible. They carry special #26 wire for concealed antennas, green rope and green insulators. They are likely to have more such specialized products in the future.

Multi-Band Antennas (7131 Owensmouth Ave., Suite 63C, Canoga Park, CA 93103) makes the well known Spider antenna. This is a mobile antenna adjustable on four bands. It starts out as a simple vertical, then sprouts several branches, each of which can be tuned for one band. This might fit nicely into a birdhouse, with the neighbors being none the wiser. There are several models of the Spider available.

Telex Communications, Inc. (9600 Aldrich Ave., So., Minneapolis, MN 55420). This company has an excellent selection of beams and also a selection of verticals that should be dead easy to camouflage. Their model 18V-S is an aluminum tube vertical, 18 feet high, for 10 through 80 meters, with a tuning coil at the base. The tap on the coil has to be changed when changing bands. It should not be difficult to conceal the coil. The Telex 12AVQ-S is a 10-15-20 meter trapped vertical, under 14 feet in height, easily hidden in a pipe or box girder. It needs only initial adjustment of its traps.

Bilal Company (137 Manchester Dr., Florissant, CO 80816) sell the Isotron antenna. These are small - smaller even than the magnetic antennas described in Chapter Three. The biggest of them, for 80 meters, is 32 x 16 x 15 inches, a package that will go under the rafters in the smallest attic. They will take 2,000 watts PEP, de-rated to 1,000 watts for indoor use. They are all single-band antennas, and are available for all the HF bands from 160 to 10 meters. Some hams put them right out in the open, on a chimney mount or similar. They do not "look like" an antenna to the neighbors. They are smaller than even an ordinary TV antenna.

Cushcraft Corporation (P.O. Box 4680, Manchester, NH 03108) supply a series of multi-band verticals. The smallest covers 10, 15 and 20 and the largest all bands from 10 through 80 meters. The 10-20 antenna would easily fit into a box girder, such as a basket-ball support. The others have a horizontal cross near the top which might be hard to disguise – bird roosts, perhaps? They also carry a series of mobile antennas. If you plan to use one indoors, remember that it is assumed these antennas will be mounted on the ground plane of the car roof.

M-2 Enterprises (7560 N. Del Mar, Fresno, CA 93711) make two and six meter "SQLOOPS," used, they say, by many hams in condos and apartments where no antennas are allowed. SQloops are horizontally polarized, and their performance depends to a certain extent on their distance from the ground and the quality of the ground. One of their two meter beams has a four foot turning radius, which sounds interesting.

AntennasWest (P.O. Box 50062, Provo, UT 84605) show several items of interest. In particular, an invisible 300 ohm indoor twin conductor on transparent tape. This sticks to walls and goes around closed doors and will carry 150 watts. This could be used to make indoor folded dipoles, as well as the intended use as a feedline. They carry a selection of mobile whip antennas and also have "Slinky" kits.

MFJ Enterprises, Inc. (Box 494, Mississippi State, MS 39762) Besides antennas, artificial RF grounds and antenna switchers, MFJ carries a wide selection of antenna tuners, from QRP random wire miniatures to 3KW state of the art units.

Allenteck (647 Arata Lane, Windsor, CA 95492) have recently started manufacturing the "SuperSpanner." Some thirty years ago I had an original Webster Bandspanner, and found it an excellent mobile all-band whip. This updated Bandspanner was reviewed in the December, 1993 issue of *CQ*. It should be dead easy to hide, and provide a most useful 80-10 meter concealed antenna.

NOTES

NOTES

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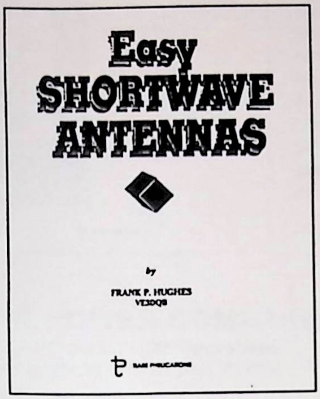

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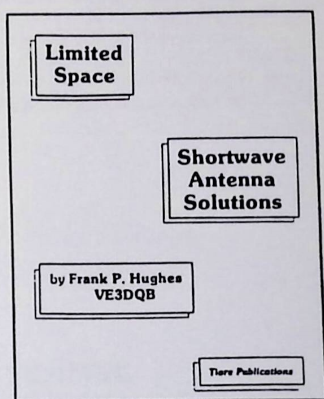

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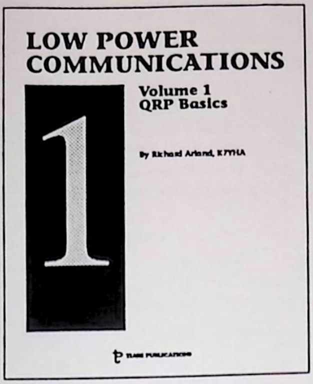

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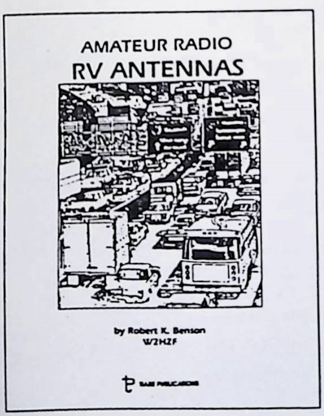

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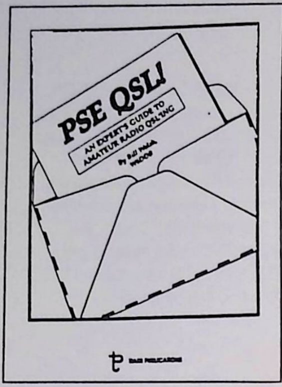

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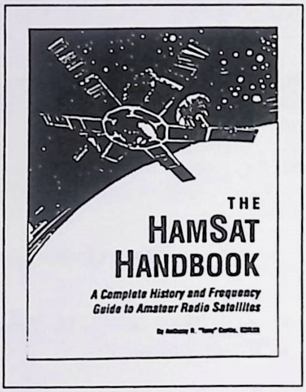

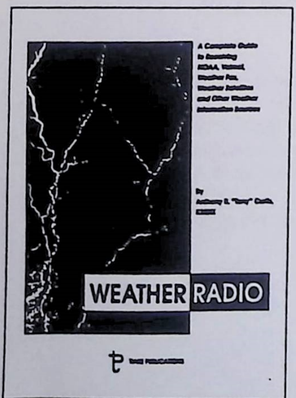

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